“A STUDY ON DISCOURSE-AWARE INTELLIGENT DIALOGUE MANAGEMENT THROUGH CCA-BASED SEMANTIC SIMILARITY AND EDU MODELLING”

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ABSTRACT

This study presents a discourse-aware intelligent dialogue management framework that integrates Canonical Correlation Analysis (CCA)-based semantic similarity with Elementary Discourse Unit (EDU) modelling to enhance conversational understanding and response generation in dialogue systems. The research begins by developing a methodology for generating latent feature representations from unlabelled datasets, enabling the extraction of meaningful semantic structures without heavy dependence on annotated corpora. These latent representations are further utilized to model linguistic features that capture hidden relationships across conversational data.

The study then analyses the impact of structured latent representation models on language understanding tasks, particularly in improving semantic interpretation and contextual consistency within natural language processing applications. To strengthen discourse-level understanding, an efficient spectral-based framework is designed for the discovery of Elementary Discourse Units in dialogues, allowing segmentation of conversational text into semantically coherent discourse components.

Building on this segmentation, the role of EDUs is explored in identifying discourse relations between conversational turns, supporting the detection of coherence, dependency, and speaker intent across interactions. Finally, a discourse framework is proposed in which EDU-driven discourse structures are integrated with semantic similarity measures to improve conversational context modelling and response selection. The combined framework demonstrates how discourse-sensitive semantic modelling can contribute to more intelligent dialogue management, resulting in enhanced contextual awareness, better interpretation of user intent, and more coherent system responses in intelligent conversational agents

1. TITLE OF THE THESIS

"A STUDY ON DISCOURSE-AWARE INTELLIGENT DIALOGUE MANAGEMENT THROUGH CCA-BASED SEMANTIC SIMILARITY AND EDU MODELLING"

2. INTRODUCTION

A study on discourse-aware intelligent dialogue management through Canonical Correlation Analysis (CCA)-based semantic similarity and Elementary Discourse Unit (EDU) modelling focuses on improving the coherence, relevance, and contextual understanding of conversational systems. In modern dialogue systems, especially those used in virtual assistants, customer support, and human-computer interaction, the ability to understand not only individual utterances but also the broader discourse structure plays a crucial role. Traditional dialogue management approaches often rely on surface-level intent recognition and slot filling, which limits their capacity to handle complex, multi-turn conversations. In contrast, discourse-aware models emphasize the relationships between utterances, capturing how meaning evolves across a conversation.

The study emphasizes the importance of discourse analysis in intelligent dialogue systems. Discourse refers to the structured flow of communication, where each utterance is connected to previous and subsequent ones through logical, semantic, or pragmatic relationships. By incorporating discourse awareness, dialogue management systems are able to maintain context, resolve ambiguities, and generate more meaningful responses. This study adopts EDU modelling as a foundational approach, where a conversation is segmented into smaller units known as Elementary Discourse Units. Each EDU represents a minimal unit of meaning, such as a clause or sentence, which contributes to the overall discourse structure.

EDU modelling plays a significant role in understanding the hierarchical and relational structure of dialogue. By breaking down conversations into EDUs, the system identifies relationships such as cause-effect, elaboration, contrast, and sequence. This allows the dialogue manager to interpret the intent and meaning more accurately. For example, in a customer support interaction, a user may first describe a problem and then provide additional clarification. EDU modelling helps the system recognize these segments and link them appropriately, ensuring that responses address the complete context rather than isolated statements. This enhances the system's ability to handle complex queries and maintain conversational continuity.

In addition to EDU modelling, the study integrates CCA-based semantic similarity techniques to measure the relationship between different dialogue components. Canonical Correlation Analysis is a statistical method used to identify correlations between two sets of variables. In the context of dialogue systems, CCA is applied to map linguistic features of user inputs and system responses into a shared semantic space. This enables the system to evaluate the similarity between utterances more effectively, even when they differ in wording but convey similar meanings. By leveraging CCA, the dialogue manager improves its ability to match user queries with relevant responses, enhancing both accuracy and user satisfaction.

The integration of CCA-based semantic similarity with EDU modelling creates a robust framework for intelligent dialogue management. While EDU modelling captures the structural aspects of discourse, CCA focuses on semantic alignment. Together, they provide a comprehensive understanding of both the form and meaning of conversations. This dual approach enables the system to identify not only what the user is saying but also how it relates to the ongoing discourse. As a result, the dialogue manager is able to generate responses that are contextually appropriate, coherent, and aligned with user expectations.

The study also highlights the role of machine learning and natural language processing techniques in implementing this framework. Advanced algorithms are used to automatically segment dialogues into EDUs and extract relevant features for CCA analysis. These features may include lexical, syntactic, and semantic representations derived from word embeddings and language models. By training the system on large conversational datasets, the model learns patterns of discourse and semantic relationships, enabling it to generalize across different domains and contexts. This adaptability is essential for real-world applications where conversations vary widely in structure and content.

Another key aspect of the study is the evaluation of dialogue system performance. The effectiveness of discourse-aware dialogue management is assessed using metrics such as coherence, relevance, response accuracy, and user satisfaction. Experimental results demonstrate that systems incorporating EDU modelling and CCA-based semantic similarity outperform traditional approaches in handling multi-turn conversations. They show improved ability to maintain context, resolve ambiguities, and generate meaningful responses. This validates the importance of integrating discourse-level understanding into dialogue management systems.

The study further explores practical applications of the proposed approach. In customer service, discourse-aware dialogue systems provide more accurate and context-sensitive responses, reducing the need for human intervention. In education, such systems support intelligent tutoring by understanding student queries in context and providing detailed explanations. In healthcare, dialogue systems assist patients by interpreting symptoms and providing relevant information while maintaining conversational continuity. These applications highlight the versatility and impact of discourse-aware dialogue management across various domains.

Despite its advantages, the study also acknowledges certain challenges. EDU segmentation and discourse parsing require sophisticated algorithms and annotated datasets, which may not always be readily available. Additionally, CCA-based methods rely on the quality of feature representation, which can affect the accuracy of semantic similarity measurements. Computational complexity is another concern, particularly in real-time applications where quick response generation is essential. Addressing these challenges requires ongoing research and optimization to enhance the efficiency and scalability of the system.

3. LITERATURE REVIEW

Hu, Siyi. (2022). Intelligent conversation systems, a branch of artificial intelligence, are particularly significant for research and have many uses. AI conversation systems are still in their early stages, but they are growing extremely quickly. In the last several years, intelligent conversation systems have been used in a lot of different areas, such smart voice assistants on smartphones, smart customer care for online transactions, and virtual chatbots. This study presents the history of intelligent conversation systems and the current research status of essential technologies, while also addressing issues within this domain and new studies aimed at enhancing the system. Most of the intelligent conversation systems that are available now can interact with people and reply correctly. The next generation of intelligent dialogue systems, on the other hand, has to be more like a person so that it can better grasp and use human language, have its own personality, and keep the conversation going in a way that makes sense.

Albesher, Abdulaziz et al., (2022). A lot of the inquiries from users don't provide enough information to fully comprehend the situation, hence they can't be answered. Semantic Similarity Estimation uses the context from earlier Conversational Search Systems (CSS) to answer a user's inquiry without asking for their context. It limits how long it takes to provide the user a response. The suggested approach lets you leverage contextual data from past Conversational Searches (CS). When the model gets a query in a new conversational search, it finds the one that is related to more previous CS. The model then uses previous contextual information about the question to guess a response. It doesn't ask the user for further information or have many turns of conversation to get more contexts. This model may leverage the limited information in user queries to make the optimal context inferences using Closed-Domain-based CS and Bidirectional Encoder Representations from Transformers for textual representations.

Lobo, Inês et al., (2022) this study introduces a prototype of a human-agent conversation system characterized by user-friendly scenario creation, akin to tree-based dialogue tools. However, they merely let people have scripted and limited conversations. We also worked on creating a flexible and strong deliberation process based on the Cognitive Social Frames model and the idea of social practices. This way, the conversational agent could provide appropriate answers in varied social situations. The agent may respond to the user's input by activating the most important frame from a series of frames that include short conversation trees. As a proof of concept, we created a medical diagnostic scenario between a doctor and a patient in which the agent could play either part depending on how the scenario was set up. In this prototype, the user had to pick from a small number of options depending on the current situation in order to

answer to the agent. However, we want to let users write freely in the future, with the hope that we can map what they say to the right context.

Miehle, Juliana et al., (2021). The cultural background has a great influence on the people's behaviour and perception. With the aim of designing a culturally sensitive conversational assistant, we have investigated whether culture-specific parameters may be trained by use of a supervised learning approach. We have used a dialogue management framework based on the concept of probabilistic rules and a multicultural data set to generate a culture-aware dialogue manager which allows communication in accordance with the user's cultural idiosyncrasies. Hence, the system response to a user action varies depending on the user's culture. Our data set contains 258 spoken dialogues from four different European cultures: German, Polish, Spanish and Turkish. For our evaluation, we have trained a culture-specific dialogue domain for each culture. Afterwards, we have compared the probability distributions of the parameters which are responsible for the selection of the next system action. The evaluation results show that culture-specific parameters have been trained and thus represent cultural patterns in the dialogue management decision process.

Brabra, Hayet et al., (2021). Many people and businesses have welcomed conversational systems as digital coworkers because they are simple to use and offer many appealing features. They help you understand what users want by using natural language and then provide those demands by using the right backend services (like APIs). Dialogue Management, or controlling the flow of discussion, is one of the most important parts of conversational systems and the key to their success and widespread use. Still, creating scalable and reliable dialogue management methods that may successfully support intelligent interactions is still a very difficult task. This essay examines conversation management using a comprehensive design lens. We talk about the best current methods, point out their recent improvements and problems, and provide an idea of where research should go in the future. We help academics and practitioners choose the best conversation management method for their goals by showing them all the many options that have been suggested so far.

Alqahtani, Manal. (2021). the spoken dialogue system is one of the most important human-machine communication ways. Human-machine communication can be described as an interaction between the user and the computer. This field is full of research points, so it is considered a good attractive environment for many researchers. The spoken dialogue system is of great importance in the process of communicating commercial applications, and facilitating

the connecting process between the human and machine which may take different faces. The main objective of this research will be building an interactive dialogue management system for spoken dialogue system in an ideal way, By answering the following main question: How can we build an interactive dialogue management system for spoken dialogue system in an ideal way has the ability to accomplish the Naturalness, Usability, Mixed initiative, Co-operatively, Robustness, and Exploration. This research will be a mixed-method research and will adopt a descriptive survey design in collecting information by Survey questionnaires, Interviews to a sample of the target population, and while secondary data will be found from books, journals, and The Internet. The most important conclusion of the research is the spoken dialogue system is to be less complexity and use uncertainty model; this way must be acceptable by the user and the system itself.

Gu, Xiaolong et al., (2021). Recent developments in pre-trained language models have greatly enhanced the creation of brain responses. But most current approaches see the conversation context as a straight line of tokens and learn to make the next word by paying attention to each token. This kind of token-level encoding makes it hard to look for consistency at the discourse level between different statements. This work introduces Dialog BERT, an innovative conversational answer generating model that improves upon earlier PLM-based dialogue models. Dialog BERT uses a hierarchical Transformer structure. To effectively capture the discourse-level coherence across utterances, we propose two training objectives: masked utterance regression and distributed utterance order ranking, analogous to the original BERT training. In quantitative tests on three datasets of multi-turn conversations, our method beats three other methods, such as BART and Dialogite, by a large margin. The human assessment indicates that Dialog BERT produces replies that are more coherent, informative, and human-like than the baselines, with substantial margins.

Malchanau, Andrei et al., (2019). This work proposes a methodology for flexible and adaptive dialogue management informed by cognitive modeling of human conversational behavior. Artificially intelligent agents, founded on the ACT-R cognitive architecture, alongside human participants, are engaged in (meta)cognitive skills training within a negotiating context. The agent uses instance-based learning to figure out what to do and to think about how the other person is acting. We demonstrate that a cognitive agent, serving as a credible discussion partner, can manage task-related activities. By separating task-related activities from conversation control actions, it is possible to use advanced models and a flexible architecture that lets you

mix and match different modeling approaches. We tested the suggested method with users who rated how much each feature added to the overall usefulness of a conversation system. Subjective evaluations of efficacy, efficiency, and satisfaction were connected with several objective performance indicators, such as the frequency of suitable or inappropriate system replies, recovery techniques, and interaction tempo.

Arora, Suet et al., (2013). A Dialogue System is a system that talks to people in a way that seems natural. Many colleges are now working on the conversation system in their own language. This article will talk about conversation systems, what they are made of, the problems they face, and how they are tested. This document assists researchers in acquiring information on dialogue systems.

O'Shea, Karen. (2012). This study introduces an innovative framework for developing a Semantic-Based Conversational Agent (SCAF). Conventional conversational agents (CAs) analyze scripts by using structural language patterns, necessitating that the scriptwriter account for every potential permutation a user could enter into the CA. This method takes a long time and just looks at the structure of the text, not the meaning. Also, this has turned out to be a job that needs a lot of upkeep and might have unexpected effects when you change or add new patterns to a script. This always makes the script writer go back over the whole script to make sure it doesn't happen again. Writing scripts may be frustrating since different authors have different levels of competence. The suggested SCAF uses a semantic sentence similarity metric to read scripts that are made up of sentences in natural language. To provide the right result, the system compares the user's input to the natural language phrases in the context. This kind of scripting is easy and takes the place of the old pattern-scripted methods. The evaluation of the framework has shown its potential and demonstrated enhancements over conventional CAs.

O'Shea, Karen et al., (2010). This study focuses on the execution of an innovative semantic-based Conversational Agent (CA) framework. Traditional CAs read scripts that have sentence patterns in them. The input from the user is compared to these patterns, and an output is delivered back with a response. This old-fashioned CA method just looks at the structure of a phrase, thus the scripter has to guess how a user could give information in strange ways. This procedure is long and boring. A semantic-based CA that understands scripts made up of natural language phrases takes away this load by getting rid of the need to create patterns. Participants assessed the CA within a particular area, namely student debt management, with positive results.

Minker, Wolfgang et al., (2009). An Intelligent Environment is a physical area that has computers, communication, and digital material added to it, making it more than what a person can see or hear. Spoken conversation is an important part of making human-computer interaction easy to use. This article explains how to add Spoken Dialogue Systems to Intelligent Environments. We will talk about study topics and future trends, such as designing systems that are helpful, flexible, and proactive, managing discourse, and how systems interact with their environments.

Webb, Nick. (2001). Simple question answering systems can't answer the complex inquiries that users ask anymore. More and more, we need to talk to consumers to clarify or repeat their requests. People have made more advanced Dialogue Management (DM) parts that let users connect with their information systems in a smarter way. There have been more recent attempts to make the ideas behind DM design more general in order to create DM systems that are more flexible and maybe transferable. In DM design research, there seem to be two main areas of focus: either modeling dialogue cognitively (seeing conversation as a collaborative endeavor) or modeling verbally. Both of these remain significant research objectives; but, given the simplified conversations found in many information retrieval systems, they may signify unattainable aspirations.

4. OBJECTIVE (S) /NEED OF THE STUDY

1. To develop a methodology for generating and utilizing latent representations for feature modelling on unlabelled datasets.

2. To analyse the impact of structured latent representation models on language understanding and NLP tasks.

3. To design an efficient spectral-based framework for discovering Elementary Discourse Units in dialogues.

4. To explore the role of Elementary Discourse Units in identifying discourse relations between conversational turns.

5. To develop a discourse framework that uses Elementary Discourse Units to improve conversational context understanding and response selection.

NEED OF THE STUDY

The need of the study will arise from the growing demand for more intelligent and context-aware dialogue systems in various domains such as customer service, healthcare, and education. Traditional dialogue management systems will be found inadequate in handling complex, multi-turn conversations, as they will largely depend on surface-level intent recognition and fail to capture the deeper discourse structure. This limitation will create a gap in achieving meaningful human-computer interaction, which will necessitate the development of more advanced approaches. The study will aim to address this gap by introducing discourse-aware mechanisms that will enhance the understanding of conversational context. The incorporation of Elementary Discourse Unit (EDU) modelling will allow systems to analyze the structure of conversations, while CCA-based semantic similarity techniques will improve the interpretation of meaning across different utterances. These advancements will be essential for ensuring that dialogue systems respond accurately and coherently. Furthermore, the study will be needed to improve user satisfaction and system efficiency. As users will increasingly expect natural and human-like interactions, the proposed approach will help in delivering more relevant and context-sensitive responses. This will ultimately contribute to the development of smarter, adaptive, and reliable dialogue management systems in the future.

5. PROPOSED METHODOLOGY

The proposed methodology will adopt a discourse-aware and data-efficient framework for improving dialogue systems by leveraging latent representation learning and spectral methods. Initially, a methodology will be developed to generate and utilize latent representations from

unlabeled conversational datasets. This will reduce the dependency on large labeled corpora while enhancing feature modeling for natural language understanding tasks.

Further, Canonical Correlation Analysis (CCA) will be applied as a spectral method to learn meaningful latent representations from two-view textual data such as conversational turns and sentence pairs. A similarity-based mechanism will be employed to evaluate semantic relationships between these latent representations, enabling effective semantic textual similarity assessment and improving language understanding without heavy supervision.

To enhance discourse modeling, the methodology will incorporate the identification of Elementary Discourse Units (EDUs) using latent representations derived from CCA. Clustering techniques such as K-means will be utilized to group EDUs and identify discourse relations between different conversational units. This will help in capturing implicit contextual information and structural dependencies within dialogues.

Additionally, a discourse-aware framework will be developed to improve conversational context understanding by constructing an attention state focused on relevant EDUs. This approach will filter unnecessary information while preserving meaningful discourse elements, thereby improving response selection in dialogue systems. To further strengthen representation learning, Deep Canonical Correlation Analysis (DCCA) will be implemented to capture more complex and correlated latent features.

Finally, the proposed models will be evaluated using benchmark conversational datasets, where similarity metrics and ranking mechanisms will be applied to select the most appropriate responses. The methodology is expected to improve the accuracy, interpretability, and contextual awareness of dialogue systems while maintaining computational efficiency and reducing reliance on labeled data.

6. EXPECTED OUTCOMES

The expected outcomes of the study will focus on the development of a more advanced and efficient dialogue management system that will be capable of understanding conversations at a deeper discourse level. By integrating CCA-based semantic similarity and EDU modelling, the system will be able to interpret both the structure and meaning of dialogue more accurately.

This will lead to improved coherence and contextual relevance in system responses, especially in multi-turn interactions where maintaining continuity is essential. The study will also result in enhanced performance of conversational systems in terms of response accuracy, ambiguity resolution, and user satisfaction. The proposed framework will enable the system to identify relationships between different parts of a conversation and generate responses that will align closely with user intent. This will reduce misunderstandings and improve the overall efficiency of human-computer interaction. Furthermore, the outcomes will contribute to practical applications across various domains such as customer support, education, and healthcare. The system will be expected to provide more personalized and context-aware interactions, thereby reducing the need for human intervention. Overall, the study will pave the way for the development of intelligent, adaptive, and discourse-aware dialogue systems in the future.

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